Greenhouse Gas Emission Analysis for the County of Sonoma

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SUMMARY

> "…*California has been lauded for leading the nation on this issue – maybe Sonoma County should be credited with leading the state*."[2]

So went a recent newspaper editorial in anticipation of the unique achievement of being the first County in the nation with the County and all city governments going on record with a commitment to reducing greenhouse gas (GHG) emissions. This analysis is the first step towards fulfilling that commitment. It discusses current efficiency projects, recommendations for future projects and the positive environmental and financial savings that Sonoma County can reap as a result of reducing GHG emissions. Furthermore, the act of providing leadership in such an important area holds the promise for much satisfaction for all involved.

The Greenhouse Gas Emission analysis for the County of Sonoma has been developed across numerous spreadsheets and is summarized with a slide presentation. It documents the following:

1. **Existing County energy-saving projects** that are reducing GHG emissions;
2. **Recommendations** for expanding existing and developing new energy reduction projects, while improving their cost-effectiveness;
3. **Support:** The knowledge base, desire, and ecological imperative to continuously improve the County's contribution to climate protection is expanding rapidly; and
4. **Positive Financial Results:** The County has the potential to stimulate durable economic development as a result of becoming an agent for actually *reducing*, instead of increasing, the overall load of greenhouse gases that threaten global climate change.

A preponderance of scientific evidence points to the need to achieve a significant reduction in greenhouse gas emissions – on the order of 70%– if we are to avoid repercussions of a scale unimaginable by most people. Although it is not within the scope of this analysis to prepare a plan for achieving so magnificent a goal, the range of GHG reduction possibilities identified herein signals that it is within reach, and that in reaching towards it we will also take significant strides towards developing an enduring economy.

The County of Sonoma is already demonstrating responsibility in climate protection. The unprecedented opportunity now to collaborate with all nine similarly committed cities in the County provides an opportunity to roll out an action plan that will deliver the kind of results that the world is waiting for.

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[1] Principal, Pacific Technology Associates (Petaluma, CA). The author acknowledges, and thanks, those who supported this analysis: County Staff (Chris Thomas, Ben Stone, Ken Wells, Bryan Albee, Dave Head, Amy Lear, John Hubiak, and Clyde Galantine), SSU's Armando Navarro, George Beeler of AIM Associates, Ed Myers and John Rosenblum of Provimetrics Corp., everyone at ICLEI, and above all, Ann Hancock, without whose vision and energy this step would not have been taken.

[2] *The Press Democrat*, 22 July 2002, Editorial, p. B8.

FINDINGS [3]

Internal Operations

Greenhouse gases are emitted by the County of Sonoma *directly*, via combustion of fossil fuels used in vehicles, for heating buildings and water, and for generating electricity used by the County; and *indirectly*, such as from emissions from transportation choices that derive from land use policy established by the County's General Plan.

This analysis addresses only activities under *direct* control of the County, and is split into two parts: (1) **internal operations**, which includes the buildings, vehicle use, and employee commute related to the County's core operations, and (2) **community services**, which include Sonoma County Transit and County Solid Waste Management operations. The Sonoma County Water Agency was not addressed.

GHG emissions related to Internal Operations are depicted in Figure 1.[4] Summary data appears in Table 1 (additional data are provided in the appendices).

Fig. 1

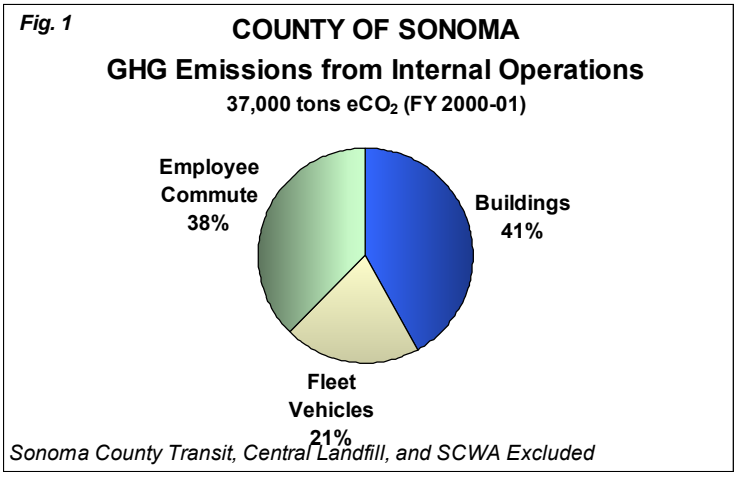

Table 1 provides a preliminary baseline against which changes in emissions may be measured. This is called a "preliminary" baseline because, as the first time through this process, not all relevant data are readily available.

For example, emissions related to commuting, identified here as a significant emissions source, requires additional and better quality information to improve the quality of the estimate (e.g., miles per trip, and people per carpool or bus, developed from a representative sample). An

[3] Readers may prefer to review the principal summary for this analysis: PowerPoint file "GHG Analysis (Aug 02).ppt," for which this report is a supplemental companion piece. Readers should also be aware that given funding limitations, this is an overview, not a definitive analysis.

[4] Emissions are expressed in tons of gas per year having a warming effect equivalent to carbon dioxide, the most abundant and cumulatively important greenhouse gas (hence units of eCO_2, equivalent carbon dioxide). County energy usage and operational data were determined using protocols promulgated by the Intergovernmental Panel on Climate Change (IPCC) as followed by the International Council for Local Environmental Initiatives (ICLEI) and the US EPA. Emissions associated with employee commute are estimated on the basis of ordinal survey data.

inventory of emissions related to employee air transportation, refrigerant leakage, and waste management (tons per year recycled, composted, or landfilled) were beyond the scope of work of this project. Based upon inventories prepared by other municipalities, however, these activities contribute relatively little to the overall total. Nevertheless, they should be tracked and included in future inventories.

Table 1	BASELINE GREENHOUSE GAS EMISSIONS				
	Tons eCO_2 Emitted, FY 2000-01 (Jul '00 - Jun'01)				
Category	**Natural Gas**	**Electricity**	**Gasoline**	**Diesel**	**TOTAL**
Buildings (energy)	5,567	9,841			**15,408**
Buildings (water & sewer)		168			**168**
Fleet Vehicles			6,232	1,425	**7,657**
Subtotal	**5,567**	**10,009**	**6,232**	**1,425**	**23,233**
Employee Commute	25	0	14,412	21	14,000
TOTAL	**5,593**	**10,009**	**20,645**	**1,446**	**37,000**

Note: *Emissions for Employee Commute are listed separately because the underlying data are much less accurate than that for other categories. Accordingly, its total and the grand total are rounded to two significant figures.*

Greenhouse gas emissions associated with the County's energy use are calculated by multiplying the amount of each type of energy consumed by its respective emission coefficient. These emission coefficients, provided within the ICLEI Climate Protection Software written by Torrie Smith Associates, are constant for Natural Gas, Gasoline, and Diesel, and variable (by year) for electricity. The emission coefficients for the first three fuels reflect eCO_2 emissions created at the point of combustion. As stoichiometric constants, these are 12.3, 21.8, and 21.3 pounds per Therm of natural gas and gallon of gasoline and diesel, respectively. GHG emissions for electricity reflect the average mix of fuels used to provide electricity in California, the heat rates of generating stations, transmission and distribution losses, and interstate power sales. The emission coefficient for FY 2000-01 is estimated at 0.553 tons eCO_2/MWh.

The procedure for inventorying the County of Sonoma's GHG emissions deserves refinement. Once this is achieved, the preliminary baseline should be adjusted to become consistent with the method developed. Future GHG emission totals may then be fairly compared against it to assess climate protection performance.

Emission Reductions: Achievements to Date

Buildings

Considerable attention has been given to improving energy efficiency of the County's buildings, especially in the central campus. Notable achievements include a **central mechanical plant**, where chilled and hot water is produced for circulation throughout the campus. This plant features thermal storage to enable off-peak chiller operation. An **energy management system** is in operation, and virtually all buildings have been retrofitted with **T-8 lighting systems**. Most recently, a **90 kW photovoltaic system** was installed atop the Information Services Building.

Fleet Vehicles

Emission reductions within vehicle fleet operations are achieved by giving **fuel efficiency** priority attention in the purchase decision, and with **proper maintenance** (e.g., regular oil

changes and proper air pressure in tires). Four 50 mpg **hybrid cars** (Toyota Prius) were added to the fleet in 2002.

Employee Commute

Among the GHG reduction schemes surveyed for Internal Operations, the prize goes to the County's employees who choose not to drive alone to work. This group, comprising less than 10 percent of the total staff in FY 2000-01, saved up to 1,000 tons eCO_2/yr relative to their solo-driving colleagues by choosing to carpool, bike, ride the bus, walk, or ride a motorcycle to work.

Current Project Spotlight Analysis—Photovoltaic Array and Hybrid Cars

The photovoltaic system and hybrid car purchases, as the most recent projects, and ones for which the relevant data are readily available, were analyzed to examine their performance in reducing GHG emissions from a financial perspective. Assuming stable future energy prices in both cases, the results are as follows:[5]

Photovoltaic System (90 kW): saves 63 tons eCO_2/yr for cost of $2,400/yr
Compared to: average electricity available via the grid in California

Hybrid Cars (4 cars): save 7 tons eCO_2/yr for cost of $1,700/yr
Compared to: four Chevrolet Cavaliers (normal County compact car choice)

Careful Design

One additional emission reduction project underway, although indirectly related to the County of Sonoma's Internal Operations, is worth mentioning. This is a City of Santa Rosa project to replace two aeration blowers at its Laguna Wastewater Treatment Plant with new units designed to consume 50% less energy than present equipment.[6] After they are installed, emissions per gallon of wastewater processed, including that discharged from the County's buildings, will decrease.

Carefully designed energy efficiency projects such as this one often deliver comprehensive benefits, including attractive financial performance. The key is to design with the intention to solve many problems at once, and to maintain the design intention throughout the life of the project. As presented above, the net lifecycle performance metrics are:

Aeration Blowers (2 each): save 2,100 tons eCO_2/yr while also saving $145,000/yr
Compared to: continued operation of existing units

[5] Net present value costs (calculations are provided in the appendices). PV system performance reflects an estimate of net emission reductions – that is, emissions saved while operating less emissions created during the manufacturing process. The crystalline PV cells employed in the County's system, for example, were likely manufactured within an energy-intensive electric induction furnace. Accurate quantification of emissions associated with PV system manufacture, however, is presently challenged by conflicting information.

[6] Hoffman blowers, controlled with inexpensive but inefficient butterfly valves, will be replaced with aerodynamically advanced units manufactured by Turblex that are controlled with variable inlet vane diffusers. Extensive datasets (meteorological, air delivery, energy, bacteriological demand) were mined to precisely model actual and desired aerator performance (service by Provimetrics Corp., Santa Rosa, CA). A performance contract, including third-party verification, will be used to maintain design integrity throughout the procurement process. This energy-saving project's favorable financial performance is enhanced with a low-interest loan provided by the California Energy Commission.

Emission Reductions: Recommendations

There are many ways to reduce GHG emissions resulting from Sonoma County's internal operations. Recommendations follow.

- **Buildings (existing)**
  - Evaluate purchasing natural gas with a contract[7]
  - Investigate energy efficiency in all detention facilities first before other buildings. (these have the highest unit energy usage)
  - Central Mechanical Plant: explore cogeneration / more efficient chillers
  - Implement daylighting improvements (designed to avoid heat gain penalty)
  - Integrate office equipment selection, furniture selection, and interior color schemes, with energy management objectives
  - Implement comprehensive water efficiency improvements[8]
  - Monitor photovoltaic system performance to improve knowledge of this technology.
- **Buildings (new)**
  - Retain integrated design experts to perform peer review as soon as possible on buildings now being designed to avoid missing savings opportunities. As increasingly demonstrated by model projects around the world, now including Sonoma State University's Environmental Technology Center, it is possible for teams of building designers, by working together and using advanced analytical tools, to reduce building energy needs by an order of magnitude less than "normal" buildings.[9] This makes it possible, for example, to achieve a climate-neutral solution with ten times fewer photovoltaic panels than are otherwise required.
  - Use Performance Based Fees when contracting for future building designs (this provides a variable professional fee based upon measured ability to achieve objectives – such as a target value for unit energy consumption)[10]

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[7] This is a key idea for quickly establishing savings with which to fund the Climate Protection Campaign. To the extent a savings opportunity exists, the ability to multiply such savings by expanding the gas purchase to include all nine Sonoma County cities that are also partners in climate protection, and Sonoma County Transit (already purchasing gas via a contract, but perhaps the additional quantity will leverage a better rate), deserves exploration.

[8] The evaluation of water saving measures for the County should ensure that the applicable financial incentives properly reflect current infrastructure cost projections (unit water efficiency incentives offered by municipal water agencies are typically too low, thereby stimulating less water savings than is economically prudent). Given the County's leadership position, it is important that each GHG reduction project it undertakes models the highest performance possible.

[9] SSU's ETC, perhaps the most carefully designed building in Sonoma County, is an important local benchmark that demonstrates the potential for energy efficiency in buildings, if not overall green design. Designed to require not more energy than 20% of the threshold established by the State of California's energy code ("Title 24"), this building used 937 Btu/sf in April of 2002 (only full month for which data were available when this report was prepared) while emitting a net 619 pounds of eCO_2 (the building is fitted with a small array of photovoltaic panels).

[10] This was used for the design of North Clackamas High School, where the school, expected to use 44% less energy than required by the Oregon Energy Building Code, will save up to $80,000/yr. The total capital cost was $118.70/sf. See Burns and Eubank, "PBFs Make the Grade," *RMI Solutions*, Summer 2002: pp. 12-13. It is far more cost-effective to design for high performance in the first place than to retrofit a sub-optimal building later.

- **Vehicle Fleet**
  - Reduce existing vehicle trips.
  - Install low rolling-resistance tires (if not already used) for replacements[11]
  - Join with other cities to order high efficiency vehicles, such as the 75% more efficient SUV proposed by the Union of Concerned Scientists (see PowerPoint file)
  - Explore use of biofuels (while considering non GHG impacts): look for possible synergy with landfill gas developments or processing of other local organic waste
  - Criteria for all decisions made about the vehicle fleet should include: lower GHG emissions, criteria pollutants, and cost[12]
- **Employee Commute**

  Many creative means have been developed internationally that reduce GHG emissions resulting from the employee commute. These include celebrating those practicing low-emission commuting, providing incentives (such as the revenue neutral Comprehensive Commuter Trip Reduction Program offered by the City of Los Angeles to 38,000 employees), and generally making cycling, pedestrian, carpool, and transit choices more attractive. Programs in this area should include extensive employee participation and education throughout their development.

Community Services

Although the initial GHG analysis undertaken by the County addresses only "internal" operations, the opportunity was taken to review and analyze data for Sonoma County Transit and Integrated Waste Management operations also. These are areas of operation over which County staff has close control and which can be used to generate climate protection credits for benefit countywide.

Emission Reductions: Achievements to Date

Sonoma County Transit is a model for its extensive use of compressed natural gas (CNG) fueled buses. Although they consume more energy per mile than their diesel-fueled counterparts, they cost and emit less – of both CO_2 and troublesome particulates.[13] The 62-bus fleet, which includes 34 CNG buses, emitted 4,972 tons of eCO_2 while providing service across nearly 1.2 million miles in FY 2000-01. Total emissions would have been ~15% greater had all the buses been diesel powered.

[11] See Option 1B in: California Energy Commission and California Air Resource Board, *Task 3: Petroleum Reduction Options*, Staff Draft Report (P600-02-011D), March 2002: 195 pp.

[12] Two issues to consider: (1) landfill gas includes trace gases that reflect that nature of the upstream economy, and that probably produce toxic combustion byproducts (see G. Tchobanoglous, H. Theisen and S. Vigil, "Integrated Solid Waste Management, Engineering Principles and Management Issues," McGraw-Hill, New York, 1993), and (2) emission of both criteria pollutants and greenhouse gases from vehicle exhaust generally lessens when moving from conventional engines to hybrid to fuel cell ("*Environmental Analysis of Fuel Pathways*," PowerPoint file by Jason Mark, Union of Concerned Scientists).

[13] SCT's CNG buses consume 10% more energy, doubtless because of the extra energy needed to compress the gas, emit 20% less eCO_2, and cost 18% less for fuel (at $0.74/Therm and $1.23/gl diesel) per mile operated than diesel buses. CNG buses are also less costly than diesel on a net lifecycle basis.

Integrated Waste Management services reveal different elements of the GHG story. Using an analytical method recently developed by US EPA, approximately 276,000 tons eCO_2/yr would be emitted if the County's entire waste stream (575,000 tons during 2001) were simply landfilled.[14] However, the County's management processes avoid 341,000 tons eCO_2/yr to yield negative total emissions of approximately –65,000 tons eCO_2/yr. The three principal processes include:

1. ***Capture and Burn Landfill Gas*** (standard practice per Federal regulations). Waste material delivered to Central Landfill is covered, and an estimated 70% of the gas generated from the decomposing mass of organic waste is captured and burned, thereby being released to the atmosphere as CO_2 instead of a mix with 55% CH_4 (methane), a gas that is 21 times more powerful than CO_2 in its climate-warming effect. These practices reduce total net emissions to –52,000 tons eCO_2/yr. The total is negative due to the effects of eliminating 70% of the methane emissions and permanently sequestering carbon within the landfill. This total is net of approximately 2,600 tons eCO_2/yr emitted by landfill operations (principally diesel-powered equipment).

2. ***Divert Waste Upstream of Landfill*** (standard practice per State regulations). At the landfill, 76,500 tons of material was diverted from the waste stream in 2001. This includes 73,000 tons of yard waste, which was composted, and 3,500 tons of ferrous metal, which was recycled (far more material is recycled by other activities upstream of the landfill, but those data were not provided for this study). Composting, a process that results in more overall CO_2 emissions for this material than landfilling, increased net emissions by 22,300 tons eCO_2/yr, while recycling ferrous metal avoided 5,800 tons eCO_2/yr across the lifecycle of future steel products. The net result of these activities is to add 16,500 tons/yr of emissions to the total.

3. ***Generate Electricity*** (option chosen by local initiative). Third, the combustion of landfill gas occurs within engines that generate electricity. During 2001, the County's eight 800 kW engine-generators produced 51,046 MWh of electricity, thereby avoiding 28,800 tons of eCO_2 that otherwise would have been emitted in the normal production of electricity for the California market.[15]

After summing the effects of these three processes, the estimated net total emissions related to the County's Integrated Waste Management service in calendar year 2001 was approximately –65,000 tons of eCO_2.

The marginal GHG emission reduction performance was calculated from the financial perspective for the CNG bus and landfill gas electricity generation measures. Assuming stable future fuel prices in both cases, the savings are as follows:

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[14] The scope of this project did not include developing the landfill model available within the software used by ICLEI (created by Torrie Smith Associates). Landfill operations were instead modeled with a simpler approach developed by EPA, upon which the ICLEI software is based. The EPA model is available at*:* *http://www.epa.gov/globalwarming/actions/waste/w-online.htm*

[15] This emissions credit is net of an emissions created during the manufacture and installation of the landfill's gas collection and energy generation (6.4 MWe) equipment. The latter (89 and 473 tons eCO_2/yr, respectively, when spread across a 20-year lifetime) were estimated using the Carnegie Mellon Green Design Initiative Economic Input-Output Life Cycle Assessment Model.

One CNG Bus @ 34,200 mi/yr: saves 22 tons eCO_2/yr and $6,660/yr
Compared to: one diesel powered bus

Next Power Unit at Landfill: saves 69,000 tons eCO_2/yr and $49,000/yr[16]
Compared to: landfill expansion without gas collection

Both approaches demonstrate *positive GHG reduction and positive financial benefits*. The GHG reduction benefit of the landfill project is much larger, mainly because of three factors: the methane gas it addresses has a global warming potential 21 times greater than carbon dioxide; carbon is sequestered; and the "fuel" source is renewable organic material (vs. mined fossil fuel).

Emission Reductions: Recommendations

This overview identifies general areas where GHG reduction projects can be developed and/or expanded.

Sonoma County Transit

- **Lower Emission (GHG) Fuels:**
  - Expand CNG program: The present fleet conversion to CNG is clearly *cost-effective and climate friendly*, and deserves additional support
  - Renewable fuel: Several possibilities exist for locally producing renewable fuel from waste biomass (e.g., manure, or municipal solid waste). The resulting fuel could be methane (compressed gas, as used today, or cold liquid), ethanol, biodiesel, or even hydrogen (again, compressed or very cold liquid). The caveats noted above in footnote 12 regarding toxic gases and air quality pollutants apply.
- **Higher Ridership:** The ability to serve more passengers per bus-mile will reduce emissions elsewhere in the Sonoma County economy, without significantly increasing SCT GHG emissions. However, collaboration with the County in reducing employee commute emissions (p. 8) is one way this can apply to direct GHG reduction within the county. For example: the City of Los Angeles' innovative Trip Reduction Program mentioned above (p. 8).
- **Improve Bus Energy Efficiency*:*** Low rolling resistance tires, discussed for passenger cars in a recent study by the California Energy Commission and California Air Resources Board, may also be appropriate for buses: it seems worth exploring (reference in footnote 11 above).

Integrated Waste Management

Already the champion of the County's current GHG reduction projects with marginal unit performance of 1.4 tons saved per $ saved, this analysis finds that even more may be done. The following strategies are suggested:

- **Reduce Mass of Waste*:*** For calendar year 2001, the County's array of operational strategies avoids approximately 0.59 tons of eCO_2 per ton of solid waste managed.[17] The EPA model used herein to evaluate this system indicates that either *reducing consumption or recycling practically any manufactured material provides far better*

[16] This includes two 800 MW engine-generators complete with incremental gas wells and piping

[17] Net 2001 GHG emission reduction of 340,000 tons eCO_2 divided by 575,000 tons of waste handled

emissions performance.[18] Better yet, when manufactured (and especially synthetic) materials are removed from the waste stream, the toxicity issues related to landfill leachate and gas will decline, and superior treatment alternatives for the remaining organic waste will become more applicable.

- **Increase Gas Production Efficiency:**
  - Central Landfill generates less gas than is normal.[19] The reason for this is unknown. If it is possible to increase landfill gas production, at least two benefits are likely: (1) additional revenue from energy, and (2) fewer years during which the County must actively manage the landfill.
  - Move past the concept of waste entirely. Further improve upstream management (reduce, reuse, recycle), and then employ high performance digesters to process the remaining organic material (including yard waste) into more gas in less time, with a relatively stable residue remaining after digestion.[20] In this scenario, a solid waste treatment facility could conceivably be an anchor tenant in an eco-industrial park, where the waste products from one enterprise are "food" or energy for neighboring enterprises, and vice-versa, decreasing GHG emissions and increasing financial savings in the business sector.
- **Develop More Value from Landfill Gas:** Internal combustion reciprocating engines, a *standard, inexpensive, and well-proven technology*, are used at Central Landfill today to drive eight 800 kW electric generators. In 2001, this system achieved a capacity factor of 91%, operated at a thermal efficiency of 26%, and grossed $3,677,525 (average price $0.072/kWh). Ways to develop more revenue include:
  - Find users for thermal energy (e.g., greenhouses co-located with landfills in Holland and Vancouver make use of heat and CO_2)
  - Evaluate and implement more efficient alternatives to present engines (e.g., industrial gas turbine, combined cycle system, or fuel cell)
  - Move gas and generators to new location having a large electrical and thermal load
  - Convert gas to a more profitable portfolio of energy products (e.g., clean CO_2 and methanol, ethanol, compressed or liquid clean natural gas (or hydrogen), and electricity).

CLIMATE NEUTRALITY AND BEYOND: Additional Possibilities

Many commendable GHG reduction programs have already begun in the County that will continue and can be expanded using the above recommendations. There are also other areas that have not been explored and are worth investigating for their potential for large GHG savings and other benefits. The cumulative effect may be for the County to achieve *climate neutrality* (or beyond): that is, where the County's GHG emissions are reduced to zero or below by investing in offsite emission reductions. Offsite projects also open the door to opportunities that are more cost-effective than those available within internal operations alone. Incontrovertible evidence identifies that products of fossil fuel combustion, and other greenhouse gases, are accumulating in the atmosphere, where they will remain for many

[18] Emission reduction data calculated for Sonoma County are reported in the appendices

[19] Noticed after reviewing unit gas production of other landfills, and work on landfill methane balances by Jean Bogner (Argonne National Laboratory); confirmed by Mr. Ken Wells.

[20] This is the approach identified in the County's Long-Term Solid Waste Management Study.

years.[21] This is what ecologists identify as the larger issue of the energy crisis: not that we might eventually exhaust the source of fossil fuels, but that we have already overwhelmed the sink (where the combustion wastes go for "processing").

Scientists have identified the need to achieve a large reduction in emissions of greenhouse gases from the human economy to keep the sink from "overflowing". The Intergovernmental Panel on Climate Change estimates that a reduction in emissions of 60 to 70 percent from 1990 levels is required to stabilize atmospheric concentrations of greenhouse gases.[22] In response, an increasing number of entities are taking action to reduce their GHG emissions by large amounts, and services are being created to assist them. For example, *DuPont* is well on its way to reducing its 1990 emissions by more than 65% by 2010.[23] *Shaklee Corporation* is one of the first California corporations to seek climate neutral status – that is, to minimize their own GHG emissions, then offset the balance by investing in projects elsewhere that will reduce their total emissions to zero.[24] Municipal agencies in the Seattle area are making magnificent strides with regard to climate neutrality (Seattle City Light has committed to achieving zero net greenhouse gas emissions).[25] Interface Corporation, the nation's largest floor covering enterprise, describes an even more impressive objective, and the means to achieve it: *going beyond zero GHG emissions to become a completely sustainable company.*[26]

These few examples are just the tip of the iceberg, so to speak. A recent *New York Times* Op-Ed piece notes enormous financial liabilities associated with global warming, and describes actions underway within investment, legal and insurance communities to address them before another "accounting scandal" appears (e.g., when off balance sheet risks materialize). Tracey Mihelic, a partner at the Baker & McKenzie law firm in Chicago, is quoted as saying about global warming: "every company is discussing this, whether or not they're saying it's an issue."[27]

This analysis has focused on means for reducing emissions at the source. The universe of project opportunities for the County is even broader. Because we are challenged by a global problem, the place at which emissions are reduced is irrelevant from a biophysical accounting perspective. However, GHG projects present variable social and economic effects. Wind, bioenergy, and community efficiency improvement projects are considered in turn to as examples to illustrate various approaches.

Wind is the fastest-growing source of power in the US and worldwide. According to the American Wind Energy Association, the cost of generating electricity is 3-6¢ per kWh and falling, making it arguably the least expensive source of renewable energy. To offset remaining

[21] Parameters for various greenhouse gases are provided in the Appendices.

[22] Houghton, Jenkins, and Ephramus, eds., *Climate Change: The IPCC Scientific Assessment*, Intergovernmental Panel on Climate Change, Cambridge University Press, 1990.

[23] See *An Overview of Greenhouse Gas Emissions Inventory Issues*, Arthur D. Little, Inc., Aug 2000: p. 40. DuPont is leveraging its GHG reduction effort by focusing on N_2O, a gas with 100 times greater global warming potential than CO_2.

[24] Offsite projects include installing high efficiency boilers for schools in Washington State, and replacing kerosene with photovoltaic lighting in Nepal. The Climate Neutral Network works with Shaklee to identify offsite projects and arrange emission savings verification – an important step to create trust.

[25] City of Seattle Resolution Number 30359, adopted 23 Jul 2001 (9-0 vote)

[26] http://www.interfacesustainability.com/

[27] Amy Cortese, "As the Earth Warms, Will Companies Pay?" *New York Times*, 18 Aug 2002 (reproduced in the appendices).

GHG emissions through credits, the County could participate as an investor in a wind energy project with the objective of earning a return, perhaps in concert with other local governments associated with ICLEI's CCP campaign. A simpler option is for the County to purchase just the GHG emission credits associated with a project that another party develops. For example, NativeEnergy, LLC, is selling "greentags" associated with wind projects to be developed by the Rosebud Sioux in a location with much stronger and steadier wind than is available in Sonoma County. The price for 8,000 tons of eCO_2 is in the region of $7.75/ton for a project with a 25-year life.[28]

Bio Energy: An approach perfectly suited to Sonoma County is participation in a bioenergy project that converts agricultural waste – particularly dairy manure – into renewable energy, fertilizer, and peat moss-like fiber. In addition to reducing greenhouse gases and eliminating pollution, such a project also serves important goals of the County's General Plan: supporting agriculture, preserving open space, and developing new economic enterprise.

The largest local source of methane emissions is probably dairy manure ponds. Following the lead of the Danish government, which is helping to develop the largest and most sophisticated system of organic waste treatment in the world, Sonoma County could help avoid approximately 200,000 tons of eCO_2/yr in the North Bay.[29] This would be a truly spectacular achievement that could carry the County (and its partners) *a long way towards, if not beyond, the zero emission Climate Neutral threshold while also addressing important local needs.*

A vacuum truck transports pathogen free, treated manure slurry from the Ribe Biogas Plant to one of 25 decentralized fertilizer storage tanks. The latter serve the 69 farms from which the manure came, and 72 others. The Ribe Plant receives as its fuel wastes from cattle, pig, poultry, and mink farms, slaughterhouses, and food processors. Energy output (heat and electricity), formerly produced by coal, is sold to the City of Ribe. This is one of approximately 20 such biogas plants in Denmark.

Improve Resource Efficiency: Akin to the above, but having more direct value throughout the County's economy, is work to cost-effectively improve resource efficiency everywhere. For example, a recent comprehensive study conducted for and now under review by the City of Petaluma shows that water efficiency services have the potential to entirely offset the 23% increase in demand expected in the non-residential sector at approximately 40% less cost than

[28] Please see Appendix F for details.

[29] This assumes ability to capture and treat half the dairy manure from the North Bay's collective herd of approximately 30,000 cows, plus additional organic waste from poultry farms and food processors, following Danish reports (e.g., Danish Centralised Biogas Plants – Plant Descriptions – May 2000). The Danish government is developing a wide range of renewable energy projects in addition to biomass.

expanding water and wastewater infrastructure.[30] Not only does this approach *avoid the incremental GHG emissions* associated with new infrastructure, it *reduces energy use, and thereby emissions, associated with existing services*. Better yet, these reductions may be amplified considerably when *energy efficiency is coupled with water efficiency* services. To carry this concept further, the dramatic energy efficiency demonstrated by Sonoma State University's Environmental Technology Center (footnote 9 above) suggests great value in establishing educational programs, coupled with appropriate incentives, throughout the development service sector (finance, design, construction, building services) to achieve this level of performance in all new buildings.[31]

IMPLEMENTATION

The following points provide an initial guide for program development. This list will naturally evolve as experience informs the process.

- Leadership and Vision
  - Elected Officials Commit to Reducing GHG Emissions
  - Clear GHG Reduction Goal Established
- Program Management
  - Establish Design Guidelines
    - Financial objectives to support a cost-effective, self-renewing portfolio of projects (i.e., a portion of all financial savings produced by projects is systematically invested in program expenses, including prospecting for further savings, thereby creating a method that ensures continuous progress)
    - Sustainability criteria established to ensure productive results[32]
  - Planning
    - Task Groups (staff, assisted by technical experts): develop specific project recommendations
    - Integrator (Sustainability Consultant): works with Task Groups to seek synergistic combinations of projects; suggests or screens "outside the box" projects, and develops annual proposed project portfolio within parameters established by Steering Committee
    - Steering Committee (Senior Staff, Public Members, and Invited Experts): periodically review overall performance, adjust goals/procedures, and recommend portfolio of projects for funding

[30] "Hold The Flow! Commercial, Industrial, and Institutional Water Efficiency Program for the City of Petaluma," Pacific Technology Associates, June 2002.

[31] Although serving far different uses, the Environmental Technology Center performed with 88 and 97 percent less energy and emission intensity, respectively, than County office buildings, during April, 2002 (the only month for which comparable data were available at the time this report was prepared).

[32] Recent work with Ecological Footprint Analysis by Redefining Progress indicates the earth's human population oversubscribes the earth's biocapacity by perhaps 30 percent. Sonoma County's ecological footprint, of which 62% is assigned to accommodate its carbon emissions, is approximately 500% larger than its global fair share. This means that potential strategies that reduce GHG emissions at the cost of increasing the ecological footprint must be avoided: both must be reduced together. The Natural Step's four system conditions are recommended as a qualitative screen to ensure movement toward sustainability.

- Transparent Process: develop method for sharing progress publicly
- Fully Integrate with Normal Operations
  - New Projects must contribute to the GHG reduction goal, just as "old" projects do (to contribute their share of the goal, this means they must be designed as well as possible to minimize emissions, and include a provision to offset elsewhere both their remaining GHG emissions and a pro rata share of the County's overall reduction target)
  - County purchases are screened for GHG emissions
- Learning Capability for Continuous Improvement (collaborate with staff of Sonoma County cities)
  - Education (e.g., global warming issues and how related to task area; aspects of system thinking and sustainability)[33]
  - Feedback (e.g., via project performance monitoring; annual County-wide emission inventory after standard technique is developed)[34]
  - Conduct research via task groups to accelerate the process (interested County/City employees supported by experts)
  - Share with Sonoma cities and others (e.g., post information on website so others may share in the learning process)

The challenge of reducing greenhouse gases is of a class that deserves reflection:

> *"The world we have created today as a result of our thinking thus far has problems that cannot be solved by thinking the way we thought when we created them." - Albert Einstein*

Effective action in the face of such a challenge calls for an unusual degree of aligned desire, hyperdisciplinary thinking, and organizational efficiency. Fortunately, skills are arising for accomplishing this: the list above anticipates their use.

One support technology that has recently been developed is the Sustainability Management System (SMS). This combines the rigor of ISO 14001 Environmental Management Systems with the sustainability action steps presented in the United Nations Environmental Programme's Local Agenda 21, and to a lesser degree inputs from various other internationally recognized environmental management protocols, to provide a best-in-class tool to achieve sustainability objectives. Furthermore, when developed simultaneously by organizations within different sectors of the economy (i.e., government, private business, NGOs, and educational institutions), Sustainability Management Systems may define ways to develop richly synergistic solutions to common issues.[35] Training and support in this technology will become available in Sonoma County beginning in 2003.

[33] Companies pursuing sustainability report that employee education is crucially important for both surfacing the best ideas, and developing enthusiastic teams with aligned action

[34] Ensure standard GHG inventory technique complies with California registration standards, if applicable

[35] Quevedo, Brew, and Hogue, "California Firms Use New Management System to Achieve Sustainability," in *International Environmental Systems Update*, January 2002: pp. 8-10.

CONCLUSIONS

The act of participating in climate protection is an opportunity to directly address one of the most important challenges faced by humankind: that of aligning our economy with the natural systems that support it. This is the kind of work that can tap the richest depths of human capability, and here we have a framework for eventually providing everyone an opportunity to participate.

This analysis only skims the range of creative responses available. Regardless of the projects chosen for implementation, it is vitally important that each of them is developed as a stellar example of what can be. While the immediate goal is to reduce emissions from County operations, high performance at each step of the way will both signal a serious intent and establish the moral authority necessary to stimulate GHG emission reductions countywide, if not beyond. Widespread action, of course, is ultimately what is needed to achieve climate protection.

Fortunately, Sonoma County does not have to invent "high performance projects," or long deliberate over which candidate projects are more worthy than others, for experience is accumulating from others who have gone first. Rare, however, is the unusual alignment toward GHG reduction in Sonoma County provided by the commitment expressed by all of its local governments. This provides a unique asset for jump-starting the County's Climate Protection Campaign: surely a "dream team" of advisors, and funds, may be attracted to help define and initiate this work. With or without their help, this new focus on reducing GHG emissions opens entirely new possibilities for the County to develop financial savings, support new businesses, create far more efficient and healthier buildings, and renew efforts to eliminate the very concept of waste. Surely this is the work of the 21st century.

APPENDICES

A. Internal Operations: Energy Use and Emissions Summary

B. Selected Data and Calculations

C. Trace Compounds in Landfill Gas

D. GHG Emissions for Alternate Waste Management Pathways

E. Characteristics of Principal Greenhouse Gases

F. NativeEnergy, LLC, Emission Offset Program

G. "As the Earth Warms, Will Companies Pay?" (NYT Editorial)

H. Material Created to Support the Analysis

APPENDIX A

Internal Operations: Energy Use and Emissions Summary

COUNTY OF SONOMA INTERNAL OPERATIONS

Summary of Fossil Energy Usage

	FUEL CONSUMPTION (FY 2000-01)				
Category	**Natural Gas**	**Electricity**	**Gasoline**	**Diesel**	
	Therms	kWh	gl	gl	
Buildings (energy)	902,051	17,794,972			
Buildings (water & sewer)		303,818			
Fleet Vehicles			571,231	133,686	
Subtotal	**902,051**	**18,098,790**	**571,231**	**133,686**	
Employee Commute	4,062	0	1,321,029	1,959	
TOTAL	**906,113**	**18,098,790**	**1,892,260**	**135,645**	

	ENERGY CONSUMPTION (FY 2000-01)				
Category	**Natural Gas**	**Electricity**	**Gasoline**	**Diesel**	**TOTAL**
	MM Btu	MM Btu	MM Btu	MM Btu	MM Btu
Buildings (energy)	90,205	60,734			**150,939**
Buildings (water & sewer)		1,037			**1,037**
Fleet Vehicles			71,804	16,350	**88,154**
Subtotal	**90,205**	**61,771**	**71,804**	**16,350**	**240,130**
Employee Commute	406	0	166,053	240	329,320
TOTAL	**90,611**	**61,771**	**237,857**	**16,589**	**569,450**

Category	COST (FY 2000-01)				
	Natural Gas	**Electricity**	**Gasoline**	**Diesel**	**TOTAL**
Buildings (energy)	$994,071	$1,610,985			**$2,605,055**
Buildings (water & sewer)		embedded			**$528,537**
Fleet Vehicles			$863,370	$159,378	**$1,022,748**
Subtotal	**$994,071**	**>$1,610,985**	**$863,370**	**$159,378**	**$4,156,340**
Employee Commute	...data not collected…				
TOTAL	**n.a.**	**n.a.**	**n.a.**	**n.a.**	**n.a.**

	BASELINE GREENHOUSE GAS EMISSIONS				
	Tons eCO_2 Emitted, FY 2000-01 (by fuel)				
Category	**Natural Gas**	**Electricity**	**Gasoline**	**Diesel**	**TOTAL**
Buildings (energy)	5,567	9,841			**15,408**
Buildings (water & sewer)		168			**168**
Fleet Vehicles			6,232	1,425	**7,657**
Subtotal	**5,567**	**10,009**	**6,232**	**1,425**	**23,233**
Employee Commute	25	0	14,412	21	14,000
TOTAL	**5,593**	**10,009**	**20,645**	**1,446**	**37,000**

Note: *Emissions for Employee Commute are listed separately because the underlying data are much less accurate than that for other categories. Accordingly, its total and the grand total are rounded to two significant figures.*

APPENDIX B

Selected Data and Calculations[36]

1. Case Studies

Case Studies.xls

COUNTY OF SONOMA: GREENHOUSE GAS REDUCTION CASE STUDIES

E. B. Orrett, P.E.

Common Reference Material

Discount Rates and Inflation Factors

Public Discount Rate: 6% rate typically used in public infrastructure planning

Energy Inflation Factors (average over 20 years):

Type	Low	High	Estimate	Notes
Electricity	0%	4%	0%	State energy bonds likely to cause rate increase
Nat Gas	0%	4%	0%	Probably rise due to increasing preference for "clean" natural gas
Liq Fuel	-4%	4%	0%	Historically shows a random real price (Rocky Mountain Institute)

General Reference for Embodied Greenhouse Gas Emissions (from mine to installed equipment / completed building)

Carnegie Mellon Green Design Initiative: Economic Input-Output Life Cycle Assessment Model

Accessible at: http://www.eiolca.net/

Conversion from 1992$ to 2001$ http://www.enr.com/cost/costcci.asphttp://www.enr.com/cost/costcci.asp

ENR 1992 Construction Cost Index	4,888	*Note: Carnegie model reports data in 1992 dollars*
ENR 2001 Construction Cost Index	6,281	*Dollars used in these Case Studies*
Ratio 2001/1992:	1.285	

Greenhouse Gas Warming Potential (metric tonnes of equivalent CO_2 per million dollars (1992 $) of activity)

	MT e-CO2/million $		tons e-CO2/million $	
Target Category	**1992$**	**2001 $**	**2001$**	**Specific Reference**
Engineering Design	194	249	226	Engineering, architectural, and surveying services
Construction	639	821	745	New office, industrial and commercial buildings construction
Photovoltaic Equip	558	717	650	Semiconductors and related devices
Turbine Machinery	756	971	881	Turbines and turbine generator sets (SIC 3511)
Passenger cars	1,016	1,306	1,184	Motor vehicles and passenger car bodies
IC Engine-Generator	950	1,220	1,107	Internal combustion engines, n.e.c.
LFG Collection Sys	644	828	751	Maintenance and repair of petroleum and natural gas wells

Unit Greenhouse Gas Emission Factors for Savings Analyses

Calif Electricity (2001)	0.575	ton eCO2/MWh	Coefficient obtained by plugging Orrett's emission data into ICLEI (
Calif Elec (Jul '00-Jun '01)	0.553	ton eCO2/MWh	use for Sonoma County Fiscal Year 2000-01 energy use data
Calif Electricity (2000)	0.531	ton eCO2/MWh	Coefficient obtained by plugging Orrett's emission data into ICLEI (
Natural Gas	0.00617	ton eCO2/Therm	See ICLEI CCP Greenhouse Gas Emissions Software, Version 5.(
LF Methane	0.0000634	ton eCO2/scf	from ICLEI (check this… seems inconsistent w/ other data)
Methane	443.5	ton eCO2/MMCF	from ICLEI (check this… seems inconsistent w/ other data)
Diesel Fuel	10.66	ton eCO2/1,000 gallon	See ICLEI CCP Greenhouse Gas Emissions Software, Version 5.(
Gasoline	10.91	ton eCO2/1,000 gallon	See ICLEI CCP Greenhouse Gas Emissions Software, Version 5.(

Volume of CO_2 Gas

Specific vol: 8.74 ft^3/lb (STP) from physical data found on the Internet

17,480 ft^3/ton (STP)

0.401 Acre Feet/ton (STP)

Biogas

Specific Gravity .	0.86	relative to air (Tchobanoglous, et al., Wastewater Engineering, 3rd Edition, p. 825)
Specific weight of air	0.0752	lb/ft3 (68 F)
Specific weight of biogas	0.0647	lb/ft3 (68 F)
Specific volume of biogas:	30,925	ft3/ton

[36] Cell notes are available in the original spreadsheets (they cannot be presented in this format)

CASE STUDY #1: Solar Photovoltaic System for County of Sonoma

Analysis by E. B. Orrett, P.E. Pacific Technology Associates

Rooftop System Parameters

Powerlight Modular System: information from John Hubiak, County Architect's Office, 1 May 2002, unless otherwise noted

Energy			
Nominal Peak Power:	90	kW	
Actual Peak Power	81.8	kW	
Annual Energy Output:	128,000	kWh	May be + or - 10%. Hubiak will closely monitor the system to learn the truth.
Energy Density			
Area of Rooftop Array	10,000	sf	
annual energy/sf	12.8	kWh/sf-yr	
annual energy/sf	43,686	BTU/sf-yr	
Financial			
Initial Cost			
Feasibility Study	$20,000		
Proj Mgmnt & Consultants	$45,500		
Installed Equipment	$681,290		
Contingency	$21,009		
Subtotal	**$767,799**		
PG&E Rebate	$340,645		
CEC Loan	$227,154	11 years	3% interest
Net County Initial Invest:	$200,000		
Net Unit Installed Cost	$43	per sf	
Annual PG&E Savings	$25,300		
Annual PG&E Increase:	0%		
County Discount Rate:	6%	applied to all case studies	Tim Holmes: 695 2158 Kenwood Energy
Net Present Value Cost:	**$58,885**	(net of PG&E Rebate) - calculations shown below	
Levelized Cost:	$2,355		
Greenhouse Gas Emissions			
Embodied Energy			
simple payback	3.5	years	estimated at 2-5 years... see http://aurora.crest.org/resources/emlists/pvusers/archives/msg00749.html
equivalent energy	450,000	kWh	
Lifetime	25	years	Solar panels have a 25-yr warranty (other system elements carry less)
Net Emission-free output	110,000	kWh/yr	annual solar kWh less embodied energy spread over system lifetime
Net Emission-free output	2,750,000	kWh	over economic lifetime of equipment
Net GHG emissions avoided	1,581	tons equivalent CO_2	(using California electricity GHG emission coefficient for 2001)
Net GHG emissions avoided	63	tons eCO2/yr	
Unit GHG emissions avoided	0.006325	tons eCO2/yr-sf (of panel)	

N.B.: a negative cost means the County saves money while reducing GHG emissions

Performance Metric	$37.24	$/ton eCO_2 avoided	w/ annual PG&E price increase of: 0%
Annual Cost	$2,355		
Performance Metric	($5.32)	$/ton eCO_2 avoided	w/ annual PG&E price increase of: 2%
Annual Cost	($336.70)		

Cash Flow Projection

	Year	Investment Cash	Investment Loan	Savings	Net Cash Flow
1	2002	$200,000	$24,550	-$25,300	$199,250
2	2003		$24,550	-$25,300	-$750
3	2004		$24,550	-$25,300	-$750
4	2005		$24,550	-$25,300	-$750
5	2006		$24,550	-$25,300	-$750
6	2007		$24,550	-$25,300	-$750
7	2008		$24,550	-$25,300	-$750
8	2009		$24,550	-$25,300	-$750
9	2010		$24,550	-$25,300	-$750
10	2011		$24,550	-$25,300	-$750
11	2012		$24,550	-$25,300	-$750
12	2013			-$25,300	-$25,300
13	2014			-$25,300	-$25,300
14	2015			-$25,300	-$25,300
15	2016			-$25,300	-$25,300
16	2017			-$25,300	-$25,300
17	2018			-$25,300	-$25,300
18	2019			-$25,300	-$25,300
19	2020			-$25,300	-$25,300
20	2021			-$25,300	-$25,300
21	2022			-$25,300	-$25,300
22	2023			-$25,300	-$25,300
23	2024			-$25,300	-$25,300

(the original cash flow table extends further)

CASE STUDY #2: Replacement High Efficiency Aeration Blower for Santa Rosa Laguna WWTP

Analysis by E. B. Orrett, P.E. Pacific Technology Associates

SYSTEM PARAMETERS

Turblex High Efficiency Blower: Information from Provimetrics Corp., Santa Rosa, CA, unless otherwise noted

Energy Savings

Nominal Peak Power:	700	kW
Annual Energy Savings:	3,700,000	kWh

Financial **2001 $ used throughout…**

Initial Cost					
Feasibility Study	$75,000				
Installed Equipment	$1,078,000				
Performance Validation	$50,000				
Contingency	$200,000				
Subtotal	**$1,403,000**				
CEC Loan	$1,278,000	6 years	3% interest	First Payment ~ Dec 2003 (after performance has been measured)	
Net City Initial Investment:	$125,000				
Annual PG&E Savings	$390,000	$0.11 /kWh		Begin early in 2003	
Annual PG&E Increase:	0%				
Annual Maintenance Cost		DISREGARD - this is required regardless if equipment is or is not upgraded			
Maintenance Inflation	2.3%	approximate value of ENR CCI annual increase			
City Discount Rate:	6%	applied to all case studies			
Net Present Value Cost:	($2,894,161)	pro forma cash flow presented below			
Levelized Cost:	-$144,708				

Greenhouse Gas Emissions

GHG Emitted

	2001$	Ton/Million	tons eCO_2	
Equipment Manufacturing	$1,117,480	881	985	
Installation	$110,520	745	82	
Design / Proj Mgmnt	$175,000	226	40	
Subtotal	**$1,403,000**		**1,107**	tons equivalent CO_2 over economic lifetime of equipment

GHG Avoided

Economic Lifetime	20	years	
Lifetime kWh avoided	74,000,000	kWh	
Emission factor	0.575	ton eCO_2/MWh	
Gross Tons eCO_2 avoided		**42,550**	tons equivalent CO_2 over economic lifetime of equipment
Net GHG Avoided		**41,443**	tons equivalent CO_2 over economic lifetime of equipment
		2,072	tons eCO_2/yr

N.B.: a negative cost means the County saves money while reducing carbon emissions

Performance Metric	($69.83)	$/ton eCO_2 avoided	w/ annual PG&E price increase of: 0%
Annual Cost:	($144,708)		
Performance Metric	($86.14)	$/ton eCO_2 avoided	w/ annual PG&E price increase of: 2%
Annual Cost:	(178,497)		

all in 2001 dollars…

Cash Flow Projection		**Investment**			
Year of Operation	**Year**	**Cash**	**Loan**	**Savings**	**Net Cash Flow**
	2001	$62,500			$62,500
	2002	$31,250			$31,250
1	2003	$31,250		-$390,000	-$358,750
2	2004		$235,916	-$390,000	-$154,084
3	2005		$235,916	-$390,000	-$154,084
4	2006		$235,916	-$390,000	-$154,084
5	2007		$235,916	-$390,000	-$154,084
6	2008		$235,916	-$390,000	-$154,084
7	2009		$235,916	-$390,000	-$154,084
8	2010			-$390,000	-$390,000
9	2011			-$390,000	-$390,000
10	2012			-$390,000	-$390,000
11	2013			-$390,000	-$390,000
12	2014			-$390,000	-$390,000
13	2015			-$390,000	-$390,000
14	2016			-$390,000	-$390,000
15	2017			-$390,000	-$390,000
16	2018			-$390,000	-$390,000
17	2019			-$390,000	-$390,000
18	2020			-$390,000	-$390,000
19	2021			-$390,000	-$390,000
20	2022			-$390,000	-$390,000

CASE STUDY #3: Hybrid Cars for County of Sonoma Fleet

Analysis by E. B. Orrett, P.E. Pacific Technology Associates

Compare the Purchase of Standard (light duty) vs Hybrid Car
Data provided and reviewed by Dave Head, County of Sonoma

Energy	**Hybrid**	**Standard**	**Δ**			
Nominal Fuel Efficiency:	50	23.5	26.5	mpg		
Annual Miles Operated:	7,000	7,000	0	miles	default value (miles/yr):	7000
Annual Fuel Consumed:	140	298	-158	gallons		
Financial						
Initial Cost	**$22,446**	**$12,208**	**$10,238**			
Annual Costs						
Maintenance	n/a	n/a		Maintenance cost a wash - same for both		
Fuel	$212	$450	-$239	Fuel Cost: **$1.51** /gl (avg for FY 2000-01 MBTE-free gasoline)		
Other	n/a	n/a		Other costs a wash - same for both		
Subtotal	**$212**	**$450**	**-$239**			
County Service Life:	7	7		years	80,000 mi or 7 yrs, whichever occurs first	
Salvage Value:	-$3,000	-$1,700	**-$1,300**	assume same % devaluation for both vehicles, until better information is available		
Annual Fuel Cost Increase:			0%	fuel cost fluctuation is unpredictable		
County Discount Rate:			6%	applied to all case studies		
Net Present Value Cost:			**$7,361**	calculation input data shown below		0%

Greenhouse Gas Emissions (all greenhouse gas emissions summarized as tons of equivalent carbon dioxide)

Embodied Energy:	14	14	**0**	tons eCO_2	Refers to Carnegie-Mellon econometric lifecycle model
Vehicle Service Lifetime:	12	12	**0**	years	guess (this includes post-County service)
Operating Emissions					
County Service Only:	11	23	**-12**	tons eCO_2	ICLEI GHG factor: 0.010906 tons eCO2/gl of gasoline
Per 4 Prius'/yr			-6.9	tons eCO_2/yr	
Miles/yr in "civilian" life:	15,000	15,000		miles/yr	Standard value used by California Energy Commission analyses
Total Vehicle Life:	27	58	**-31**	tons eCO_2	
Total Lifetime Emissions					
County Service Only:	25	37	**-12**	tons eCO_2	
Total Vehicle Life:	42	72	**-31**	tons eCO_2	
Net GHG emissions avoided					
County Service Only:			**12**	tons eCO_2	
Total Vehicle Life:			**31**	tons eCO_2	
Performance Metric					
County Service Only:			**$611**	$/ton eCO_2 avoided	By selling a hybrid instead of a regular car into the
Total Vehicle Life:			**$241**	$/ton eCO_2 avoided	"civilian" fleet, additional GHG savings accrue.
NPV Cost/4 cars/yr:			**$1,662**		

Cash Flow Projection

Hybrid vs. Standard Compact Car: Net Cash Flow				
Year	**Net Cost**	**Net Savings**	**Net Cash Flow**	**Cumulative Cost**
2002	$10,238	-$239	$9,999	$9,999
2003		-$239	-$239	$9,761
2004		-$239	-$239	$9,522
2005		-$239	-$239	$9,284
2006		-$239	-$239	$9,045
2007		-$239	-$239	$8,806
2008		-$239	-$239	$8,568
2009	-$1,300	-$239	-$1,539	$7,029

CASE STUDY #4: Natural Gas Buses for Sonoma County Fleet

Analysis by E. B. Orrett, P.E. Pacific Technology Associates

Compare Diesel to Natural Gas fueled Buses
Data provided and reviewed by Bryan Albee, Sonoma County Transit

Parameter	BUS BY FUEL TYPE Natural Gas	Diesel	TOTAL	Units	Supplementary Data Cost	Emissions tons eCO_2	Energy MMBtu
Service Provided							
Miles/year	1,164,604	615,886	**1,780,490**	miles			
Number of Buses	34	28	**62**				
Miles/bus-yr	34,253	21,996	***28,718***	***(avg)***			
Fuel Consumed							
Natural Gas	440,043		**440,043**	Therms	$327,612	2,716	44,004
Diesel		172,401	**172,401**	gallons	$212,879	1,838	21,079
Gasoline	25,080	13,264	**38,344**	gallons	$38,299	418	4,819
Cost	$352,663	$226,127	**$578,790**				
Cost per mile	$0.303	$0.367					
Emissions							
Total	2,989	1,983	**4,972**	tons eCO_2/yr			
Unit (per mile)	5.1	6.4		lb/mile			
Energy Use							
Total	47,156	22,746	**69,902**	MM Btu/yr			
Unit	40,491	36,932		Btu/mile			
Lifecycle Cost Data							
Bus	*County Discount Rate:*		*0%*	*(cash basis)*			
Capital Cost	$365,000	$280,000					
BAAQMD Rebate	$150,000	$0					
Net	$215,000	$280,000					
Bus Lifetime	15	15		years			
Annual Cap Cost	$14,333	$18,667					
Annual O&M	$15,701	$12,698	*N.B.: older diesel fleet*				
Subtotal	**$30,034**	**$31,365**					
Fueling Station	*County Discount Rate:*		*6%*				
Capital Cost	$1,800,000	$1,000,000					
Plant Lifetime	15	18					
Annual Cap Cost	$185,333	$92,357					
Annual O&M	$80,000	$5,000					
Subtotal	**$265,333**	**$97,357**					
Subtotal (per bus)	**$7,804**	**$3,477**					

Average Bus Weight: 20 tons

LIFECYCLE ANALYSIS

Determine Unit Cost to Avoid Emissions
Unit of Analysis: One Bus

Average Annual Miles/Bus: 34,253
(use same miles for each type of bus)

	Natural Gas	Diesel
Capital Cost		
Bus	$14,333	$18,667
CNG Plant	$5,451	$3,298
Subtotal	**$19,784**	**$21,965**
Annual Cost (at 34,253 mi/yr)		
O&M (bus)	$15,701	$19,774
O&M (fueling)	$1,973	$179
Fuel	$10,372	$12,576
Subtotal	**$28,046**	**$32,529**
Total Cost/yr	**$47,830**	**$54,494**
eCO2/yr (tons)	**87.9**	**110.3**

$/ton CO_2 Avoided (@ $0.35/Th): **($526)**
$/ton CO_2 Avoided (@ $0.74/Th): **($298)**

@ $0.74/Th: 6.7 lb avoided/$ saved
Total Now Avoided: 760 tons eCO2/yr
Annual Cost: $226,556

The calculations related to the Landfill (marginal performance of increasing LFG collection system and electrical generation capacity by 1.6 MW) are too extensive to easily replicate here. Please refer to the original spreadsheet.

SUMMARY OF CASE STUDY PERFORMANCE METRICS

Project	Capital Cost (gross)	Annual Cost (NPV)	Annual Savings (tons eCO_2/yr)	Project Performance (tons eCO_2/$)
LFG System	$2,592,938	($48,770)	69,134	(1.418)
W/W Aerators	$1,403,000	($144,708)	2,072	(0.014)
CNG Buses	$12,410,000	($226,556)	760	(0.003)
PV Solar	$767,799	$2,355	63	0.027
Hybrid Cars	$89,784	$1,662	7	0.004

Notes

General Notes: (1) Annual costs are calculated in a lifecycle basis. They are net of any rebates, reflect actual interest rates as applicable, and are discounted to the present, when applicable, at 6%. Fuel price escalation rates are set to zero. (2) Annual emission savings are net of estimated embodied emissions (except for the buses and cars, where the reference case is other buses and cars). (3) When the annual cost for a project is negative, GHG savings are achieved at a "profit."

LFG System: Revenue from electricity provides a negative annual cost (net present value) over the 20-year life of the equipment (two new 800 MW generators and associated Landfill Gas wells and pipes). The large GHG savings are due mostly to the capture of methane gas and conversion, in the generator, to CO_2.

W/W Aerators: City of Santa Rosa project to install two new aeration blowers for the Laguna Wastewater Treatment Plant that will use 50% less electricity than the original units.

CNG Buses: The 34 buses operating on compressed natural gas, relative to diesel buses, emit less GHGs and cost less to operate. They also emit far fewer particulates.

PV Solar: The County's new photovoltaic system is estimated to save a net of 63 tons of eCO_2 per year for 25 years. Whether or not this project will save money is dependent upon (1) the future price of electricity, (2) durability of solar system performance, and (3) maintenance costs. For simplicity, the values above assume no price escalation, no deterioration, no maintenance, and a life limited to the system warranty of 25 years.

Hybrid Cars: This reflects the performance of four Toyota Prius cars relative to $12,200 Chevrolet Cavaliers (the default compact car). This also assumes continued emission savings while in private hands after being retired from County service.

2. Relationship of Water and Wastewater Usage with Energy Usage
Water & Wastewater Assumptions.xls

COUNTY OF SONOMA GREENHOUSE GAS EMISSION STUDY
Emissions Related to Water and Wastewater Utilities E. B. Orrett 9 May 2002

Data Source: Water and Wastewater Efficiency / Avoided Cost Study, Montgomery Watson and Pacific Technology Associates, Sep 95

WATER
Emissions are due to:
1. Energy used to pump and treat water (kWh/gl * gl used)
2. Embodied energy in water supply infrastructure
3. Net effect due to reservoirs (loss of vegetative CO2 uptake; CH4 emitted by inundated vegetation)

Due to the survey nature of this project, we will assume the latter two sources are insignificant, and evaluate only the first.

Source data used to develop p. 5-31 of the SCWA report referenced above is worked with below:

Energy Using Point	Energy	Volume	Santa Rosa Fraction			Unit Energy	
	kWH/yr	AF/yr	%	AF	kWh	kWh/AF	kWh/1,000 gl
Wohler Booster	34,686,628	58,109	39%	22,529	13,448,090		
Sonoma Boosters #1 and #2	2,755,360	7,499	9%	675	247,982		
Wilfred Booster	1,064,800	22,529	100%	22,529	1,064,800		
TOTAL	**38,506,788**	**n/a**	**n/a**	**22,529**	**14,760,872**	**655**	**2.01**

Note: SCWA pumps all water from the river via the Wohler Booster, then to Santa Rosa via Wilfred (and some from the Sonoma Boosters)

WASTEWATER
Emissions are due to:
1. Energy used to pump and treat wastewater - dry weather flow only; I&I doesn't count (kWh/gl * gl used)
2. Embodied energy in wastewater infrastructure
3. Uncaptured methane emissions generated within the wastewater system
4. Net effect due to reservoirs (loss of vegetative CO2 uptake; CH4 emitted by inundated vegetation)

Due to the survey nature of this project, we will address only the first (the data are time-intensive to assemble).

Table D-2 of above SCWA document provides the following unit energy costs:

	Unit Energy Costs ($/MG)			
	Effluent Destination		Total	
	Laguna	Irrigation	Weighted Average	Total
Pertinent 1993/4 Volume (MG):	2,412	3,720		6,132
	$/MG	$/MG	$/MG	
Santa Rosa Collection System				
Lift Stations	$3.89	$3.89		
Laguna Treatment Plant				
Pumping	$59.22	$59.22		
Disinfection	$26.33	$26.33		
Disposal Pumping				
to Laguna	$18.55			
to Irrigators		$130.23		
Total $/MG DWF:	**$107.99**	**$219.67**	**$175.74**	per million gallons

And with that, estimate kWh/unit volume:

Unit Energy Consumption

1. Estimate avg 1993/94 unit electricity cost

From 1994 annual summary of SCWA PG&E energy cost: Average cost = $0.0602/kWh

2. If we assume the bulk of Santa Rosa's power is billed on the same rate schedule used by PG&E for the Water Agency (because the Laguna Plant is a huge load), we then have:

2.92 kWh/thousand gallons of wastewater

SONOMA COUNTY EMPLOYEE COMMUTE E. B. Orrett 8 May 2002

Data Source:
Transportation Survey Summary produced by SP3 Committee (by Transportation and Public Works Dep't?)
Summary Report provided by Charlotte Fisher (Integrated Waste Division)

Data Collected: October 2000

Commuting Population:

Surveys Distributed:	3,919
% of County Workforce:	80%
Total Workforce:	4,899

Surveyed Population

Surveys Completed	1,426

Transportation Used:

		days/wk
Carpool	7%	4
Bicycle	2%	3
Motorcycle	1%	3
Bus/Transit	2%	3
Walk	1%	3
Drive Alone	86%	not reported
	99%	

Transportation Impact per Year

Assumptions

weeks per year	48
miles per day	25
default transport	Drive Alone
total employee days	1,175,700
avg vehicle mpg	20.8
carpool occupancy	2.3

Estimate average commute miles/day per employee
1) Based upon estimated commute time reported on survey:
avg commute time: 40 min/day avg mph: 30 avg mi/d: 20
2) Based upon estimated commute distance reported in survey:
30 miles (twice the weighted average miles to work, taken from chart reporting data for ~250 employees)
Average Commute: 25 miles

Source: March 2002 draft report published by Calif Energy Commission: Task 3 Report on Petroleum Reduction Options (data is average vehicle efficiency for Califc
persons/car (total guess: two people per car is the minimum for a carpool; this assumes 30% higher)

SUMMARY BY CATEGORY

Category	people	avg mi per day	person miles/yr	persons per vehicle	Vehicle miles/yr	Fuel	Vehicle Btu/mile (fossil energy)	Miles per Fuel unit	Units of Fuel per Year	Fuel unit	eCO2 per mile (lb)	tons eCO_2/yr	tons eCO_2 per employee-yr	additional assumptions
Carpool	274	25	1,645,980	2.3	715,643	gasoline	n.a.	20.8	34,406	gl	1.05	375	1.4	average commute time/distance a
Bicycle	59	4	56,434	1	56,434	bio	0	0	0	n.a.	0.00	0	0.0	guess at distance - less than the a
Motorcycle	29	25	176,355	1	176,355	gasoline	n.a.	50	3,527	gl	0.44	38	1.3	average commute time/distance a
Bus/Transit	59	10	141,084	9.2	15,335	several						0		guess at distance - probably less t
Bus (CNG)					10,031	CNG	40,491	2.47	4,062	therm	5.0	25		actual SCT fuel efficiency; pro rata
Bus (Diesel)					5,305	diesel	36,932	2.71	1,959	gl	7.9	21		actual SCT fuel efficiency; pro rata
Weighted Avg						mix				mix	6.0	n.a.	0.8	pro rata of two rows above
Walk	29	1.5	10,581	1	10,581	bio	n.a.	0	0	n.a.	0	0	0.0	guess at distance - must be much
Drive Alone	4,448	25	26,688,390	1	26,688,390	gasoline	n.a.	20.8	1,283,096	gl	1.05	13,987	3.1	average commute time/distance a
Total	**4,899**	n/a	**28,718,824**									**14,447**	**2.9**	

APPENDIX C

Trace Compounds in Landfill Gas

Typical Concentrations of Some Trace Compounds found in Landfill Gas	
Component	**Mean Concentration** (ppbV)
Toluene	34,907
Dichloromethane	25,694
Ethyl Benzene	7,334
Acetone	6,838
Vinyl Acetate	5,663
Tetrachloroethylene	5,244
Vinyl Chloride	3,508
Methyl Ethyl Ketone	3,092
Xylenes	2,651
1,1-Dichloroethane	2,801
Trichloroethylene	2,079
Benzene	2,057

Source: *Tchobanoglous, Theisen, and Vigil, "Integrated Solid Waste Management, Engineering Principles and Management Issues, McGraw-Hill, NY, 1993. Information presented at: http//www.zerowasteamerica.org/Landfills.htm*

APPENDIX D

GHG Emissions for Alternate Waste Management Pathways

GREENHOUSE GAS EMISSION REDUCTION

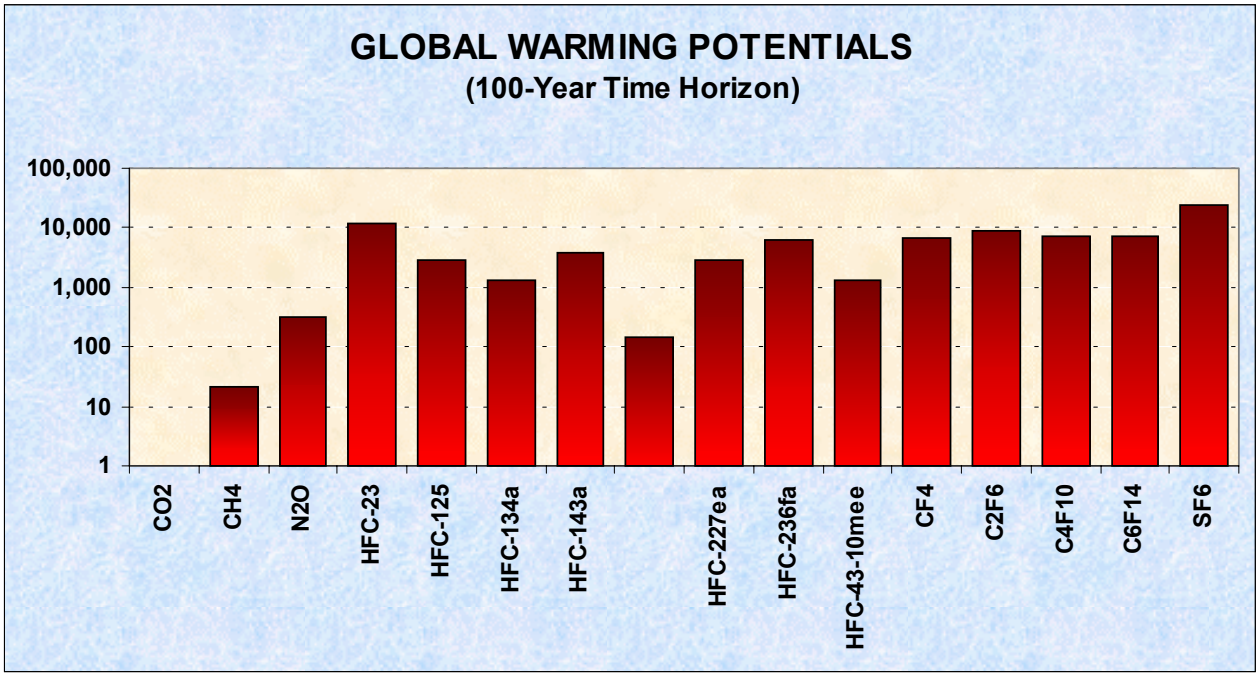
Tons eCO_2 per Ton of Material Processed

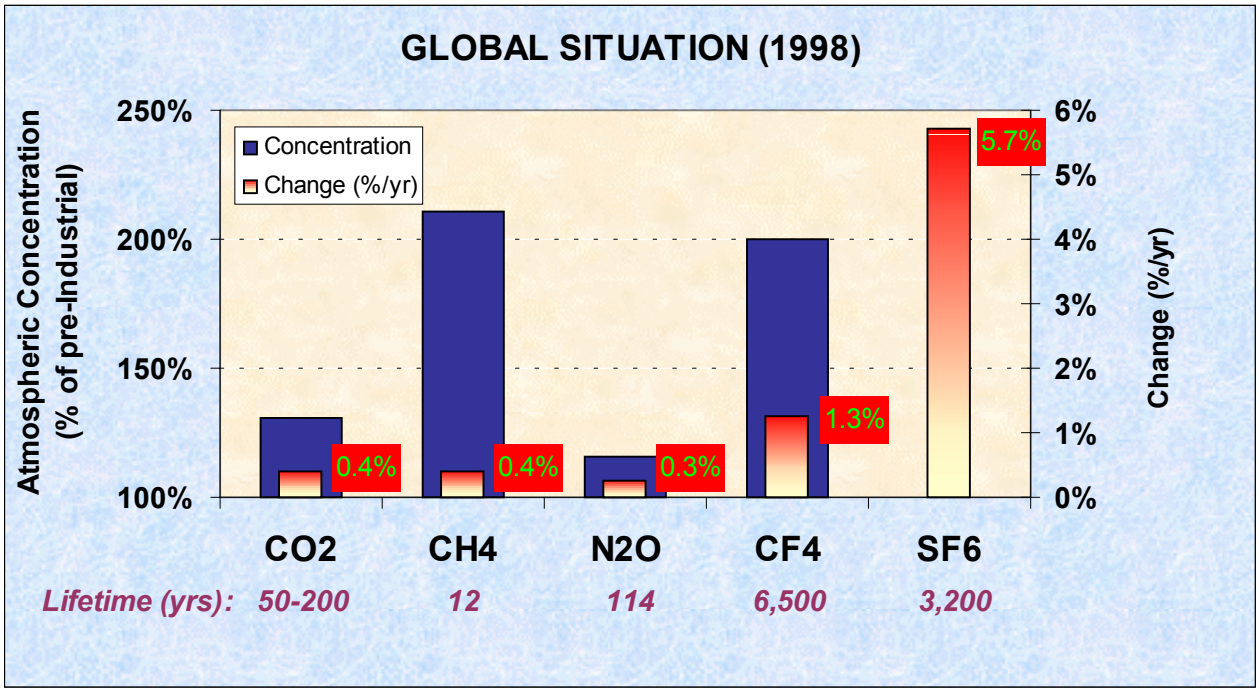
MATERIAL	MANGEMENT ALTERNATIVE			
	Reduced	Recycled	Landfilled	Composted
Inorganics				
Aluminum Cans	8.30	13.67	-0.03	n.a.
Mixed Metals	NA	5.90	-0.03	n.a.
Steel Cans	2.62	1.63	-0.03	n.a.
Glass	0.45	0.25	-0.03	n.a.
Paper				
Phonebooks	4.26	3.03	1.02	n.a.
Mag/3rd-cl mail	3.44	2.45	0.77	n.a.
Newspaper	2.70	3.16	1.02	n.a.
Office Paper	2.68	2.25	-0.56	n.a.
Corrugated	1.71	2.36	0.42	n.a.
Plastics & Lumber				
LDPE	2.04	1.55	-0.03	n.a.
HDPE	1.62	1.27	-0.03	n.a.
PET	1.62	1.41	-0.03	n.a.
Mixed Plastics	NA	1.37	-0.03	n.a.
Dimensional Lumber	1.83	2.23	0.56	n.a.
Organics				
Leaves	n.a.	n.a.	1.18	0.18
Branches	n.a.	n.a.	0.56	0.18
Yard Trimmings	n.a.	n.a.	0.55	0.18
Mixed Organics	n.a.	n.a.	0.25	0.18
Grass	n.a.	n.a.	0.23	0.18
Food Scraps	n.a.	n.a.	-0.15	0.18

Source: *Data generated by Pacific Technology Associates via US EPA WARM Model (configured to represent Sonoma County's Cetnral Landfill by assuming 70% LFG recovery for energy)*

APPENDIX E

Characteristics of Principal Greenhouse Gases





APPENDIX F

NativeEnergy, LLC, Emission Offset Program

Date: Fri, 2 Aug 2002 10:24:01 -0400
From: "Thomas E. Stoddard" <tom.stoddard@nativeenergy.com>
To: <pacific@sonic.net>
CC: "Boucher" <tom.boucher@nativeenergy.com>

Hi Ned - thanks for your interest.

For 8,000 (short) tons, we can offer a price around $7.75 per ton. We believe that our prices are very competitive with CO_2 offsets from existing "new" wind farms generally, but ours have the following additional value:

> (i) It is a futures-based life-of-project[37] purchase that actually helps drive the construction of a specific new wind farm. In other words, it is a truly "new" wind farm, not because it was built after a certain date, but because it isn't yet built. Your purchase will have what the Climate Neutral Network has referred to as "super-additionality" in that it helps drive new construction and helps create new environmental benefits.
>
> (ii) It helps drive construction of the first Native American-owned large-scale wind turbine, which is the first step in a sustainable economic development program for the Rosebud Sioux Tribe. Your purchase will help create significant educational and economic benefits for the Rosebud Sioux Tribe in addition to the environmental benefits.

As to 8,000 tons "per year", our program also has a considerable advantage. Next year, your county would be helping build a different new wind farm. Our futures-based model is designed to bring the wind turbine/farm its life-of-project above-market revenue requirements all at once, when it reaches commercial operations. It's good to go at that point, and we move on to support the next turbine/farm. That way our purchasers aren't stuck continuing to support a turbine that was once deemed "new", but once some years have gone by, really isn't. Every year our customers help build a NEW new wind turbine/farm.

As to double counting, we've had long experience with that issue from our early days at Green Mountain Energy. First, we have ensured that we have the sole contractual rights to the green tags from our share of the Rosebud turbine. Second, we've precluded the Rosebud Tribe from selling the underlying energy to anyone unless they: (a) sell it as a generic, undifferentiated electricity commodity only, giving no rights to any of the environmental attributes to the electricity purchaser; (b) obtain the purchaser's acknowledgement that the green tags have been sold to NativeEnergy; and (c) obtain the purchaser's agreement not to make any claims that the electricity is wind-generated or otherwise has any environmental attributes other than those of the grid mix of energy at the time. Third, we require our individual purchasers, and give our bulk commercial/insititutional purchasers the option, to donate the property they purchase - the present ownership of the future stream of green tags (a commodity futures contract with green tags as the commodity) to our environmental partner, Clean Air - Cool Planet. CA-CP is a 501(c)(3) environmental organization whose primary charitable purpose is "reducing global warming". For our bulk commercial/institutional purchasers, who don't need the charitable

[37] Project life, per contract, is 25 years. Telephone conversation Ned Orrett / Tom Stoddard 12 Aug 02.

donation deduction, CA-CP promises to retire the green tags - they will make no further use or transfer of them except to the extent necessary or advisable to effect the retirement of them under applicable law (such as transfer to a state agency legally charged with retiring green tags/TRCs, as in the Texas model). For individuals, CA-CP promises either to retire the green tags or use them in ways that will keep as much CO_2 out of the air as retiring them would - this gives CA-CP the necessary control and discretion over the donated property to preserve the deductibility for the individual donors, while making sure that their purchase has the desired effect - CO_2 reductions (as an example, CA-CP could sell the tags, but would have to use the proceeds to buy and retire as much (or more) CO_2 offsets from another (perhaps less expensive) source. These precautions are more than adequate to avoid double-counting.

Finally, on the double counting issue, the turbine is being built in South Dakota, which has no RPS or environmental disclosure regulations that would require the "counting" of the generic energy as wind-generated, which raises double-counting issues in some states, like New York.

Something you didn't ask about - our CO_2 offsets from the Rosebud turbine are pre-qualified for inclusion in a Climate Neutral Network-certified "Climate CoolTM" portfolio. This means that if your organization wished to be certified as Climate CoolTM by the CN Network, it would need only to have its CO_2 footprint verified/certified by the CN Network. Use of our offsets to offset its footprint would avoid having to go through CN Network's certification of the offsets too - ours are ready to go. We went through that process with the CN Network in connection with their certification of the Dave Matthews Band 2002 tour, for which we provided 85% of the offsets.

Check out this article on our offsetting Ben & Jerry's 2002 emissions from its production and corporate office facilities
http://www.newstream.com/story_pub.shtml?story_id=6673&user_ip=66.82.97.
We've also offset emissions for The Timberland Company, Co-op America, The Utne Reader and many other businesses, and we're in discussions/review with several other national and international businesses right now.

I hope that you find this information both helpful and compelling. Please feel free to contact me directly for further information. In any case, we applaud your action in the fight against global warming and climate change.

Tom Stoddard
NativeEnergy, LLC
(802) 453-7821
(802) 877-6826
tom.stoddard@nativeenergy.com

APPENDIX G

"As the Earth Warms, Will Companies Pay?" (NYT Editorial)

August 18, 2002

By AMY CORTESE

GLOBAL warming has been on the agenda of environmental activists for years. But it is also becoming a green issue of another kind - discussed not only in terms of melting ice caps and endangered species, but as a problem that can cost corporations and their investors billions of dollars.

With their confidence shaken in corporate bookkeeping and the market's omniscience, investors are starting to look for other possible "off balance sheet" land mines, including the hidden risks that could be associated with global climate change.

A scientific consensus has formed that greenhouse gases - carbon dioxide and other heat-trapping emissions released by automobiles, power plants and industrial factories - are causing the average temperature to increase, setting off environmental reactions ranging from rising water levels to droughts.

Losses from global warming were in evidence just this past week. A report released last Monday by the United Nations predicted that a two-mile-thick layer of brown haze blanketing Asia, caused in part by greenhouse gases, could severely cut rainfall and reduce India's rice harvest by 10 percent. And abnormally high temperatures in Eastern Europe have been partly blamed for the severe floods ravaging Prague and other beacons of European architecture.

Munich Re, a large German insurance company, estimates that global warming could cost $300 billion annually by 2050 in weather damage, pollution, industrial and agricultural losses and other expenses. Companies may also face unexpected expenses because of compliance with future regulations, fines, taxes and caps on products that produce greenhouse gases.

The impact of climate change varies by sector. Oil, gas and utilities, of course, are directly affected by changes in energy policy, while real estate is affected by coastal flooding and drought. But environmental activists and a growing number of investors have started to catch the corporate world's attention with their warnings that nearly all industries are exposed to some risk. Of particular concern are the costs of complying with a patchwork of regulations in the United States and abroad and the potential harm to a company's reputation if it is contributing to global warming.

In another ominous sign for chief executives and board members, some experts in corporate governance say company officers could be held accountable for failing to protect their companies from climate-related risk. And the lawsuits could come from governments as well as investors and other aggrieved parties. Peter Lehner, chief of the New York attorney general's Environmental Protection Bureau, said it was studying the issue of climate change and might sue polluters along the lines of the successful tobacco litigation by states in the 1990's.

YET most of the risks and potential costs go unreported. Although Securities and Exchange Commission rules require companies to disclose trends and uncertainties that could affect their stocks, few specific provisions exist for disclosing environmental liabilities. Critics say that even those regulations are barely enforced and that financial analysts rarely take such risks into account when assessing companies.

It's not necessarily deliberate. In many cases, companies are unsure how to calculate potential liabilities - especially when regulations have yet to be written. Because global warming is a long-term trend, it does not fit neatly into the quarterly reporting schedule or the outlook of many executives.

Still, many investors are taking such omissions seriously. "There was an assumption that everything important was valued by the market," said Robert K. Massie, executive director at the Coalition of Environmentally Responsible Economies, an association of environmental and investor groups that is based in Boston. "We know now that investors can be unaware of something with big impact."

Robert Monks, chairman of LENS Investment management and Ram Trust Services, and a longtime corporate governance activist, said companies need disclosure guidelines for environmental liability because "the market can't reflect something it doesn't know."

Mr. Monks was behind a shareholder resolution this year aimed at reducing the duties of Lee Raymond, chairman and chief executive of Exxon Mobil, to mitigate what Mr. Monks saw as the damaging effects of Mr. Raymond's rigid view that global warming was not a problem for the company. The resolution got 20 percent of the vote, considered surprisingly strong.

The issue of executive and director liability is likely to be closely watched. Shareholder activists "are creating a record of these companies' being put on notice," said Christopher Walker, managing director of a group that assesses the insurance risks of greenhouse gases at the New York offices of Swiss Re, a large insurer. "Our concern is, will there be a shareholder action 5 or 10 years from now?" In particular, he said, emissions reduction is shaping up as a "clear liability issue" for corporate managements and boards.

Swiss Re is reviewing the companies it insures to determine what they are doing to manage climate change risk, he said, and is considering excluding from coverage companies or directors that are not addressing it.

Some companies, like DuPont, BP and Ford, have addressed risk from climate change in their annual reports and S.E.C. filings. In its 2001 annual report to the S.E.C., for example, DuPont acknowledged the possible consequences of the Kyoto treaty on greenhouse emissions. Although not ratified by the United States, the treaty will limit gases like carbon dioxide and nitrous oxide, which DuPont produces in chemical manufacturing. DuPont's report said it has been reducing these emissions since 1991, yet may still face further restrictions in some countries.

IN contrast, Dow Chemical, a competitor, does not mention climate change or greenhouse gas emissions in its 2001 annual report to the S.E.C.

"We're going to be saying more about climate change," said Peter Molinari, a Dow executive who monitors climate change and the company's greenhouse gas emissions. For example, a social responsibility report to be released by Dow in September will chart its greenhouse gas emission reductions (15 percent since 1995) for the first time, Mr. Molinari said.

Advocates of more disclosure say that in lieu of hard numbers, even qualitative assessments are helpful. Pressure for such assessments has been growing. Shareholder resolutions that ask companies to disclose or reduce greenhouse gas emissions won an unexpectedly high 30 percent of the vote at some companies during the 2002 annual meeting season. Law firms and insurance companies are setting up business units to deal with climate-related risks. And more institutional investors are lobbying the S.E.C. and companies for better disclosure of environmental risks, particularly those related to climate change.

"People are recognizing that it's an issue they are going to have to deal with," said Tracey Mihelic, a partner at the Baker & McKenzie law firm in Chicago and a member of its new practice dealing with energy and climate-change litigation.

Tim Little, executive director of the Rose Foundation for Communities and the Environment, a shareholder advocacy group based in Oakland, Calif., that has been campaigning for clearer guidelines on environmental reporting, said, "We see environmental disclosure as the next big corporate accounting scandal out there."

A report being drafted by the foundation predicted shareholder losses from "fines, penalties, and cleanup costs due to violation of environmental laws, increased costs due to changes in environmental regulation, and greater-than-expected costs due to understated or undisclosed liabilities."

Innovest Strategic Value Advisors, based in New York, estimates that as much as 15 percent of the total market capitalization of major companies may be put at risk by climate change.

A report in July by the World Resource Institute, an environmental research group, said shareholders in leading oil and gas companies could lose 6 percent or more of the value of their investments because of regulatory and other efforts to curb climate change. Of the 17 companies studied, only three - British Petroleum, Conoco and Phillips Petroleum - mentioned in their annual reports that climate policies and regulations could affect future business operations.

Big names are behind some of the campaigns. In May, Rockefeller Philanthropy Advisors in New York organized the Carbon Disclosure Project, a petition supported by institutional investors representing $4 trillion in assets from Credit Suisse, Domini, Merrill Lynch Investment Managers and UBS Global Asset Management, among others. The investors wrote to 500 large corporations asking them to quantify their greenhouse gas emissions and plans for reducing them.

For many corporations, the process of even starting to calculate liability is difficult, because liability is contingent on future regulations. In addition, a single company can have several areas of seemingly insignificant risk that become significant when added up.

"How do you know what your risk is when the rules are not yet established?" said Ms. Mihelic of Baker & McKenzie. She said that if companies take action before regulations are in place - say, building a more efficient plant - those actions may not count toward credits when regulations are written years later.

"If I'm a board of directors, am I going to spend $100 million?" she asked. "If I address it now, are you going to sue me for addressing it too soon?"

Nonetheless, she said, "every company is discussing this, whether or not they are saying it's an issue."

[38] E-mail from David Seitz (Rights & Permissions, The New York Times) to Edwin Orrett dated Thu, 19 Sep 2002 08:45:40 -0700

APPENDIX H
Material prepared by Pacific Technology Associates to Support the Analysis

Name	Function
Summary	
GHG Analysis (Aug 02).ppt	Summary presentation of entire analysis
Summary Material.xls	Compiles overall GHG emissions across County operations. Includes breakout of fossil energy use within Internal Operations.
Case Studies.xls	Develops performance metrics for various GHG reduction projects currently underway
ICLEI Software Output.xls	Summary reports developed on basis of Sonoma County data
Buildings	
Facility Energy Usage & Cost.xls (formerly Site Use&Cost 00v01.xls)	Electricity and natural gas usage and cost data, with summaries: July 2000 – Jan 2002
County of Sonoma building data.xls	Provides area, floors, construction year, # occupants, lighting type, hours of operation
Irrigation.xls	Cost & usage data (irrigation only): July 2000 – Jan 2002 (small file)
Wastewater.xls	Cost & usage data (wastewater only): July 2000 – Jan 2002 (small file)
Water & Wastewater Analysis.xls	Water usage & cost data plus estimate of indoor and outdoor usage and cost for 2001
Commute	
Employee Commute Data and Assumptions.xls	Provides raw data and all assumptions made to estimate emissions
Background	
2001 Calif Elec Emission Coefficients.xls	Estimates GHG emission coefficients for California Electricity (2000 and 2001)
Bills vs reports.xls	Tests (and confirms) that the County's Utility Manager software accurately assigns data from billing periods to calendar months
Water & Wastewater Assumptions.xls	Develops kWh/thousand gallon coefficients for City of Santa Rosa water and wastewater services used by the County of Sonoma